

## Results of taking turbine units 1 and 2 out of service to reduce water temperatures in the McNary collection channel and juvenile fish facility.

The evaluation was originally scheduled for 12 days (July 20 - July 31) but was reduced to 11 days due to a possible power shortage on July 31. Units 1 and 2 were taken out of service from noon to 10 p.m. on 5 days (July 22, 23, 26, 27, 30). Water temperatures were monitored in the turbine unit gatewells, forebay, collection channel, separator, and one raceway. Water temperatures were recorded every half-hour. Prolonged wind speeds in excess of 4mph are sufficient to mix water in the McNary forebay and reduce or eliminate thermal gradients (Figure 1). Wind velocities averaged above 4 mph on 7 days (Table 1). There were a total of 6 days in which wind did not have a major influence on test conditions, 4 days were in the "on" (all units operating) operation (July 20, 24, 28, 29) and 2 days in the "off" (units 1 and 2 off) operation (July 23, 27).

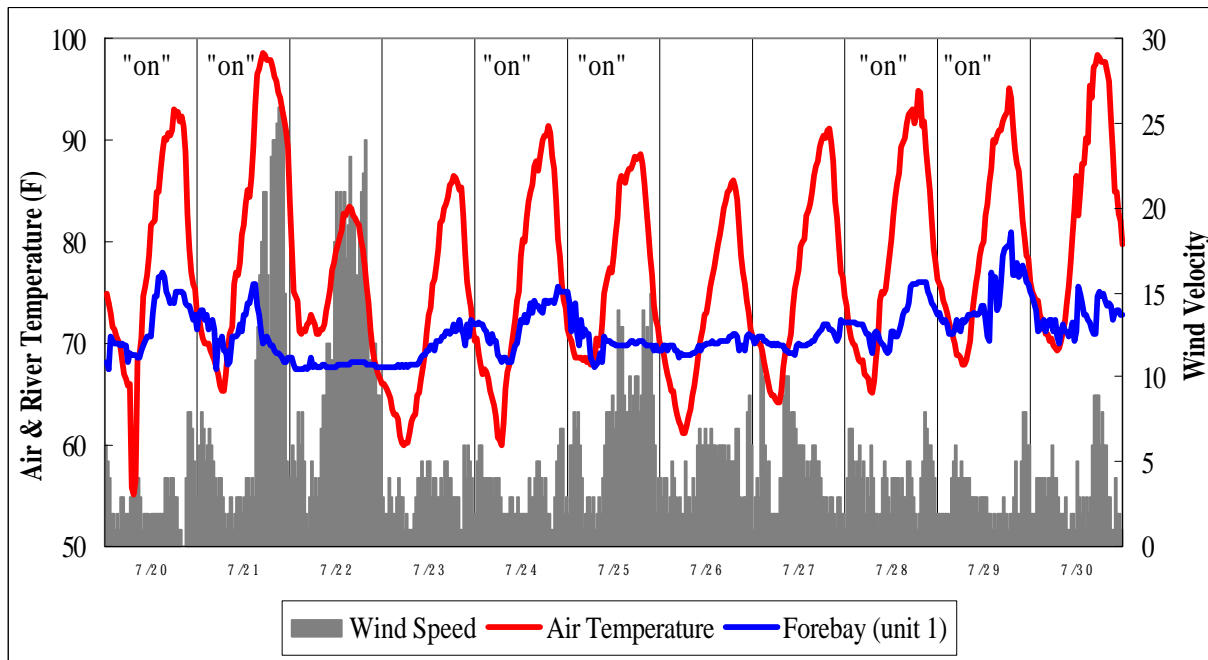


Figure 1. Air temperature, wind speed, and forebay (unit 1) water temperature at McNary Dam.

Direct comparison of the data, disregarding the effects of air temperature and wind speed, showed a decrease in average water temperatures and peak daily temperatures in the separator, collection channel, raceways, and the transport pipe from the collection channel to the separator when units 1 and 2 were off (Table 1). Water temperatures at the separator averaged  $0.6^{\circ}\text{F}$  lower than with all units in operation and the peak daily temperature averaged  $0.8^{\circ}\text{F}$  cooler. Water temperature in the transport pipe from the collection channel to the separator was an average of  $0.8^{\circ}\text{F}$  lower with units 1 and 2 out of service and the peak daily temperature averaged  $1.3^{\circ}\text{F}$  cooler. The larger decrease in water temperature in the transport pipe is due to the addition of cooler water from the gatewells of units 1 and 2 into the lower end of the collection channel just prior to the entrance to the transport pipe. Similarly, when units 1 and 2 are operating the warmer water from the gatewells increase water temperatures in the transport pipe (Figure 2).

Table 1. Average and peak daily temperatures during unit operation testing at the McNary Project.

Average Daily Temperatures (12 p.m. - 10 p.m.)													
Date	Trans Pipe	Separator	Raceway	Channel (6ft) (12ft)		Gatewells 1 2 3 4				Air Temp Avg max		Wind Avg max	
20-Jul-00	70.4	69.9	70.0	70.6	70.1	72.8	72.1	71.7	72.4	87.8	89.4	2.9	7.2
21-Jul-00	70.4	70.3	70.4	70.3	70.2	70.4	70.0	70.0	70.1	93.7	94.9	15.4	25.6
22-Jul-00	68.3	68.2	68.2	68.2	68.0	68.2	68.1	68.1	68.1	78.5	79.5	17.8	37.6
23-Jul-00	69.3	69.1	69.1	69.2	69.3	68.3	68.2	69.6	70.4	81.4	82.8	3.7	8.2
24-Jul-00	70.7	70.1	70.2	70.9	70.5	73.3	72.4	71.9	71.5	85.5	86.8	3.3	7.0
25-Jul-00	69.4	69.3	69.2	69.2	69.1	69.9	69.8	69.7	69.5	84.6	85.6	10.4	21.5
26-Jul-00	69.9	69.8	69.7	69.7	69.6	69.6	69.4	70.1	70.2	80.5	81.4	5.3	11.6
27-Jul-00	69.8	69.7	69.7	69.7	69.7	69.3	69.2	70.2	70.5	85.8	86.9	4.0	8.8
28-Jul-00	70.8	70.3	70.4	70.9	70.4	73.6	72.8	71.7	71.9	89.5	90.8	4.1	9.4
29-Jul-00	71.9	71.3	71.5	72.1	71.9	73.6	74.1	73.3	74.0	88.1	89.6	2.9	6.4
30-Jul-00	71.9	71.3	71.3	71.8	72.1	69.7	70.0	72.9	73.0	92.4	94.0	4.4	9.4
on (avg)	70.6	70.2	70.3	70.7	70.4	72.2	71.9	71.4	71.6	88.2	89.5	6.5	12.9
off (avg)	69.8	69.6	69.6	69.7	69.7	69.0	69.0	70.2	70.4	83.7	84.9	7.0	15.1
on vs off	0.8	0.6	0.7	1.0	0.6	3.2	2.9	1.2	1.2				

Daily Peak Temperatures (12 p.m. - 10 p.m.)													
Date	Trans Pipe	Separator	Raceway	Channel (6ft) (12ft)		Gatewells 1 2 3 4				Air Temp Avg max		Wind Avg max	
20-Jul-00	71.0	70.1	70.3	71.4	71.0	74.4	74.6	73.3	74.0	93.0	94.0	8.0	25.0
21-Jul-00	71.9	71.6	71.5	71.7	71.6	74.4	71.8	71.5	71.3	98.5	99.1	26.0	39.0
22-Jul-00	68.3	68.4	68.3	68.4	68.3	68.7	68.3	68.2	68.3	83.6	85.1	24.0	50.0
23-Jul-00	69.8	69.5	69.7	69.9	70.4	68.7	69.1	70.6	72.2	86.4	87.2	6.0	12.0
24-Jul-00	71.9	71.0	71.2	72.3	71.9	74.7	74.6	74.2	74.3	91.5	92.5	7.0	14.0
25-Jul-00	69.8	69.5	69.4	69.3	69.2	70.5	70.3	70.3	70.1	88.6	89.3	15.0	32.0
26-Jul-00	70.1	70.1	69.7	69.9	70.1	70.5	70.3	70.9	71.0	86.0	86.8	7.0	16.0
27-Jul-00	70.1	70.1	70.0	70.5	70.4	70.5	70.3	71.2	71.6	91.1	91.6	6.0	13.0
28-Jul-00	71.6	70.7	70.9	71.7	71.3	75.6	75.5	73.0	73.4	94.9	96.9	8.0	16.0
29-Jul-00	73.4	72.5	73.0	73.8	73.7	76.2	77.1	76.1	76.5	95.1	97.0	8.0	14.0
30-Jul-00	73.1	72.2	72.4	72.9	73.4	73.5	73.9	74.8	74.6	98.3	99.1	9.0	16.0
on	71.6	70.9	71.1	71.7	71.4	74.3	74.0	73.0	73.2	93.6	94.8	12.0	23.3
off	70.3	70.1	70.0	70.3	70.5	70.4	70.4	71.1	71.5	89.1	90.0	10.4	21.4
on vs off	1.3	0.8	1.1	1.4	0.9	3.9	3.6	1.9	1.7				

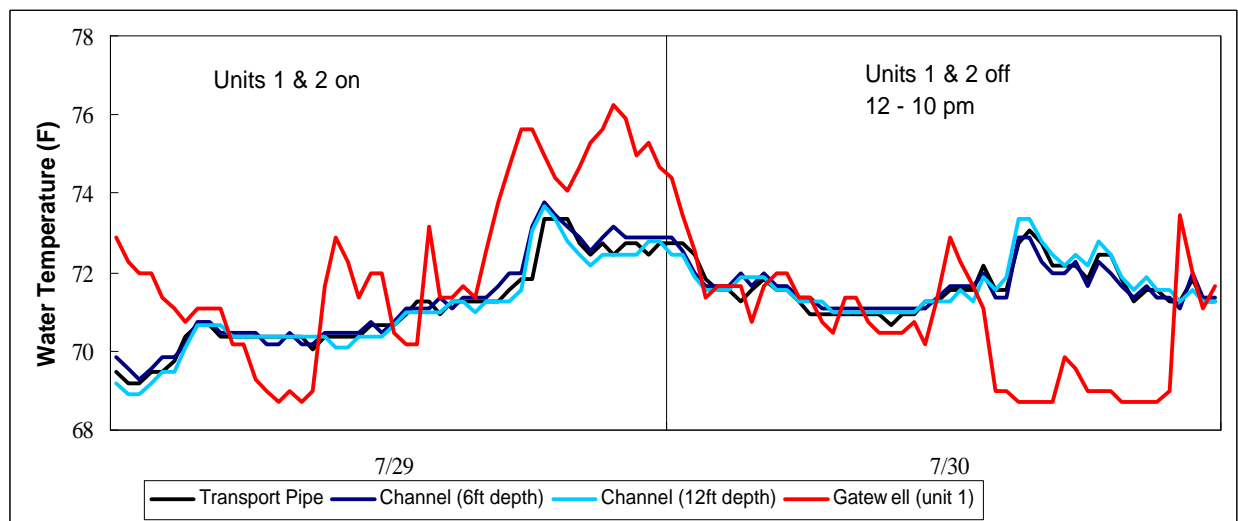


Figure 2. Influence of gatewell water temperature on the collection channel and transport pipe.

Air temperature and wind play a significant role in the creation of thermal gradients in the McNary forebay. The evaluation was designed to have comparable baseline conditions (air temperature, wind speed, initial river temperature) in order to determine the effects of the "off" and "on" operations on water temperatures in the collection channel and facility. High winds, as stated previously, eliminated all or a significant portion of the thermal gradients on five days (July 21, 22, 25, 26, 30) of the evaluation. Comparison of days that were not affected by wind showed an average decrease in water temperature at the separator of 1.0<sup>0</sup>F and the peak daily temperature dropped an average of 1.3<sup>0</sup>F when units 1 and 2 were not operated (Table 2). Water temperature in the transport pipe from the collection channel to the separator decreased an average of 1.5<sup>0</sup>F and peak daily temperature decreased an average of 2.0<sup>0</sup>F. Additionally, operating gatewell temperatures averaged 1.3<sup>0</sup>F cooler and peak daily gatewell temperature decreased an average of 3.5<sup>0</sup>F (Figure 3 & Figure 4). It should be noted that air temperatures during the "on" operating days averaged 4.1<sup>0</sup>F warmer and wind averaged 0.6 mph lower than the days units 1 and 2 were not operated. Also, additional units were down during part of the test period on July 23, 28, and 29.

Table 2. Average and peak daily temperatures during unit operation testing, McNaryProject.

Average Daily Temperatures (12 p.m. - 10 p.m.)													
Date	Trans Pipe	Separator	Raceway	Channel (6ft) (12ft)		Gatewells 1 2 3 4				Air Temp Avg max		Wind Avg max	
20-Jul-00	70.4	69.9	70.0	70.6	70.1	72.8	72.1	71.7	72.4	87.8	89.4	2.9	7.2
23-Jul-00	69.3	69.1	69.1	69.2	69.3	68.3	68.2	69.6	70.4	81.4	82.8	3.7	8.2
24-Jul-00	70.7	70.1	70.2	70.9	70.5	73.3	72.4	71.9	71.5	85.5	86.8	3.3	7.0
27-Jul-00	69.8	69.7	69.7	69.7	69.7	69.3	69.2	70.2	70.5	85.8	86.9	4.0	8.8
28-Jul-00	70.8	70.3	70.4	70.9	70.4	73.6	72.8	71.7	71.9	89.5	90.8	4.1	9.4
29-Jul-00	71.9	71.3	71.5	72.1	71.9	73.6	74.1	73.3	74.0	88.1	89.6	2.9	6.4
on (avg)	71.0	70.4	70.5	71.1	70.7	73.3	72.8	72.2	72.4	87.7	89.1	3.3	7.5
off (avg)	69.5	69.4	69.4	69.4	69.5	68.8	68.7	69.9	70.4	83.6	84.8	3.9	8.5
on vs off	1.5	1.0	1.1	1.7	1.2	4.5	4.1	2.3	2.0				
Daily Peak Temperatures (12 p.m. - 10 p.m.)													
20-Jul-00	71.0	70.1	70.3	71.4	71.0	74.4	74.6	73.3	74.0	93.0	94.0	8.0	25.0
23-Jul-00	69.8	69.5	69.7	69.9	70.4	68.7	69.1	70.6	72.2	86.4	87.2	6.0	12.0
24-Jul-00	71.9	71.0	71.2	72.3	71.9	74.7	74.6	74.2	74.3	91.5	92.5	7.0	14.0
27-Jul-00	70.1	70.1	70.0	70.5	70.4	70.5	70.3	71.2	71.6	91.1	91.6	6.0	13.0
28-Jul-00	71.6	70.7	70.9	71.7	71.3	75.6	75.5	73.0	73.4	94.9	96.9	8.0	16.0
29-Jul-00	73.4	72.5	73.0	73.8	73.7	76.2	77.1	76.1	76.5	95.1	97.0	8.0	14.0
on	71.9	71.1	71.4	72.3	71.9	75.2	75.4	74.1	74.5	93.6	95.1	7.8	17.3
off	69.9	69.8	69.9	70.2	70.4	69.6	69.7	70.9	71.9	88.8	89.4	6.0	12.5
on vs off	2.0	1.3	1.5	2.1	1.5	5.6	5.7	3.2	2.6				

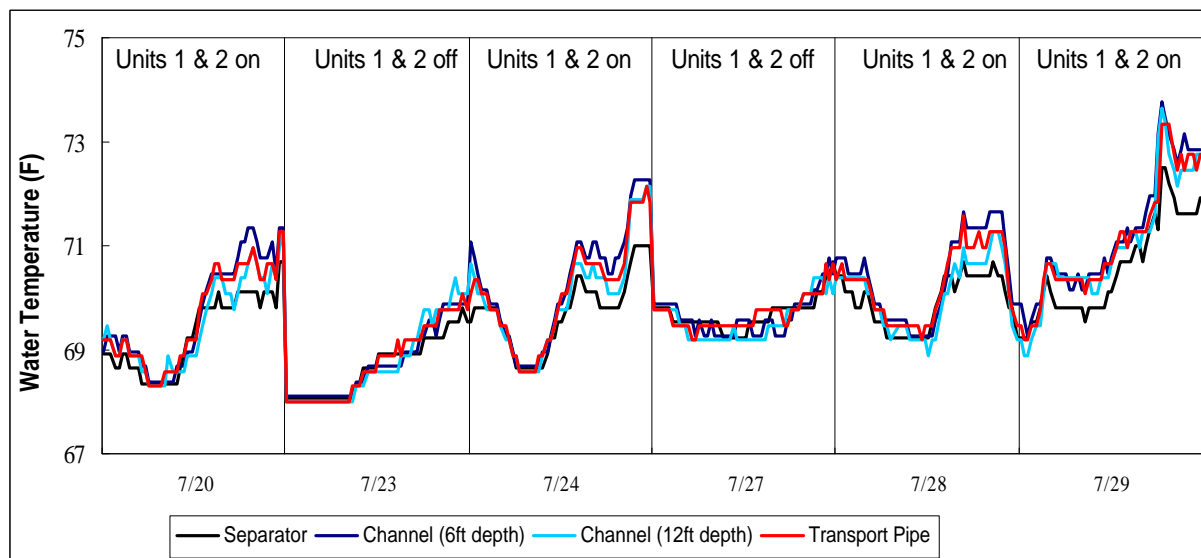


Figure 3. Comparison of separator, collection channel, and transport pipe temperatures during "on" and "off" operation, McNary.

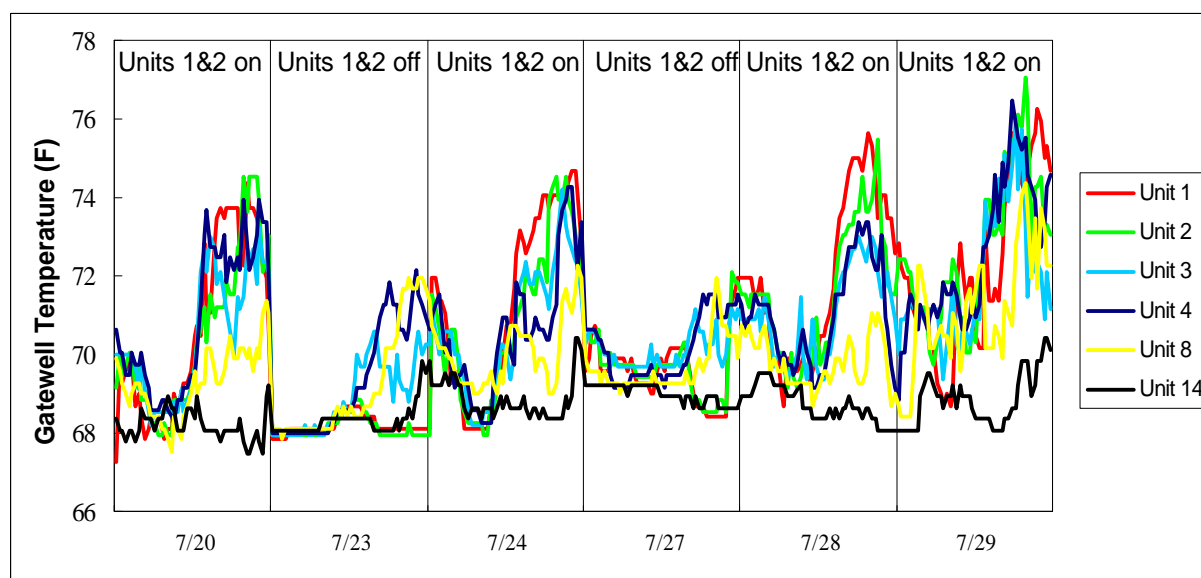


Figure 4. Comparison of gateway temperatures between "on" and "off" operation, McNary.

Temperature gradients between the turbine unit gatewells and the collection channel were also monitored during the evaluation. Typically, the largest temperature gradients occur at the southern end of the powerhouse. Average temperature gradient with units 1 and 2 off was  $0.6^{\circ}\text{F}$  compared to  $1.4^{\circ}\text{F}$  with all units operating (Table 3 & Figure 5). Peak daily temperature gradients between the gatewells and the channel were reduced from  $2.8^{\circ}\text{F}$  to  $1.7^{\circ}\text{F}$ .

Mortality rates were similar for both operations. System mortality averaged 1.4% when all units were operating and 1.1% with units 1 and 2 off (Figure 6). Sample tank mortality averaged 1.2% during the "on" operation and 1.3% during the "off" operation.

Table 3. Average and maximum temperature gradients between the collection channel and the turbine unit gatewells, 12 p.m. - 10 p.m.

Average						
Unit	20-Jul-00	23-Jul-00	24-Jul-00	27-Jul-00	28-Jul-00	29-Jul-00
1	2.7	-1.0	2.8	-0.5	3.2	1.6
2	2.2	-1.2	2.1	-0.5	2.7	2.4
3	2.0	0.2	1.8	0.5	1.7	1.8
4	3.0	1.1	1.5	0.8	2.1	2.7
5	1.8	1.1	1.6	0.8	1.8	2.9
6	1.6	1.2	1.4	0.7	1.5	3.2
7	1.0	1.0	0.9	0.9	0.9	1.7
8	1.0	1.1	0.9	0.7	0.7	1.7
9	0.8	0.9	0.8	0.7	0.8	1.1
10	0.7	0.8	0.9	0.6	0.9	1.3
11	0.4	0.4	0.5	0.3	0.4	1.0
12	0.4	-0.2	0.5	0.2	0.4	1.0
13	0.5	0.2	0.5	0.1	0.4	0.7
14	0.0	0.0	0.0	0.0	0.0	0.0
Avg*	1.3	0.7	1.2	0.5	1.3	1.7
Avg "off"		0.6	Avg "on"		1.4	
Maximum						
Unit	20-Jul-00	23-Jul-00	24-Jul-00	27-Jul-00	28-Jul-00	29-Jul-00
1	4.2	0.1	4.4	0.9	5.0	4.0
2	4.9	0.5	4.9	1.1	4.7	4.3
3	3.4	1.8	3.3	1.7	2.9	4.6
4	4.5	2.3	3.3	2.0	3.7	6.1
5	4.0	2.5	4.3	1.9	3.2	5.8
6	3.1	2.2	2.5	1.9	3.9	6.5
7	1.6	2.3	2.2	2.3	1.5	3.2
8	1.7	2.4	1.8	2.3	1.8	3.1
9	1.4	2.0	2.5	1.6	1.6	3.2
10	1.5	2.1	2.2	1.7	1.9	3.2
11	2.2	1.9	1.5	1.5	1.1	2.3
12	0.9	0.3	1.0	1.0	0.7	2.9
13	1.2	1.2	1.2	0.9	1.2	2.4
14	0.0	0.0	0.0	0.0	0.0	0.0
Avg*	2.5	1.7	2.5	1.6	2.4	3.7
Avg "off"		1.7	Avg "on"		2.8	

\* Average includes operating units only

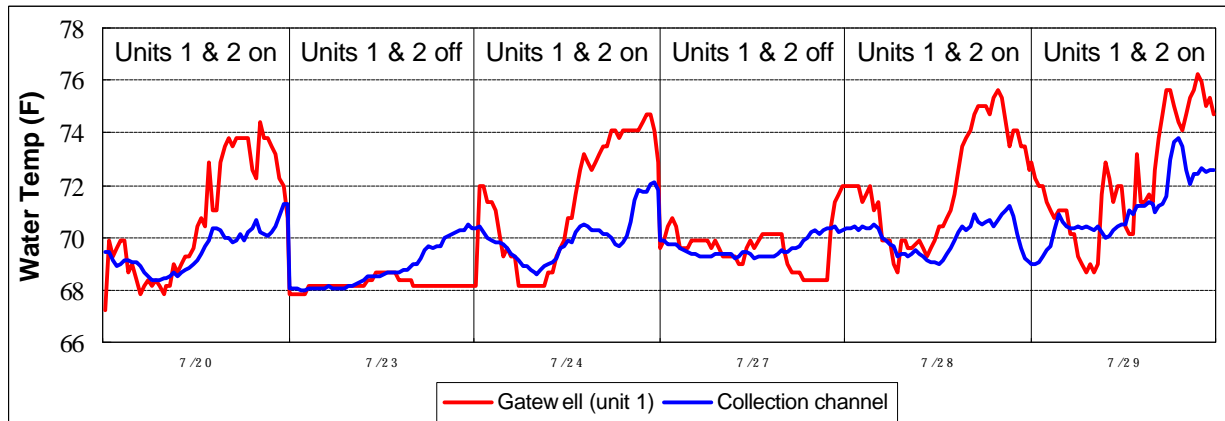


Figure 5. Temperature gradients between the collection channel and turbine unit 1 gateway.

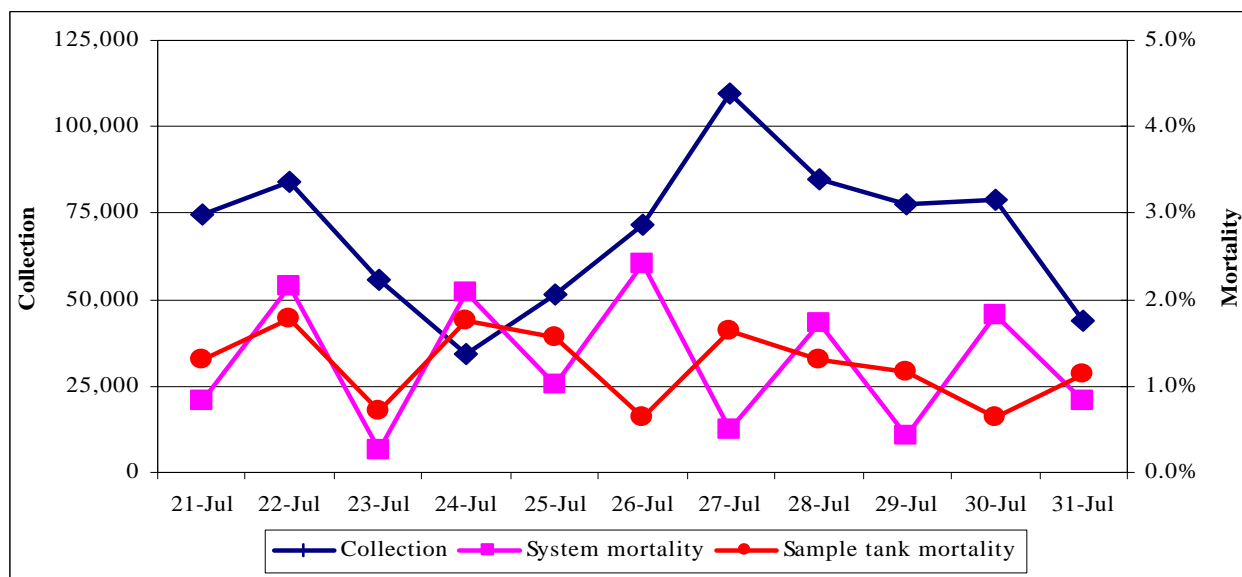


Figure 6. Collection, system mortality, and sample tank mortality during powerhouse operation testing.

### Summary

Taking turbine units 1 and 2 out of operation will decrease the average and daily peak water temperatures in the collection channel and at the juvenile fish facility by approximately 1°F. Additionally, average water temperature in the pipe from the collection channel to the separator could be lowered roughly 1.5°F and peak daily temperature in the pipe could be lowered 2°F. Average operating gateway temperatures were 1.3°F cooler and peak daily gateway water temperatures decreased an average of 3.5°F when units 1 and 2 were off. Temperature gradients between the turbine unit gatewells and the collection channel were also reduced with units 1 and 2 off. Average temperature gradient with units 1 and 2 off was 0.6°F compared to 1.4°F with all units operating. Peak daily temperature gradients between the gatewells and the channel were reduced from 2.8°F to 1.7°F. Conditions during testing were not identical between "on" and "off" operations but were similar.

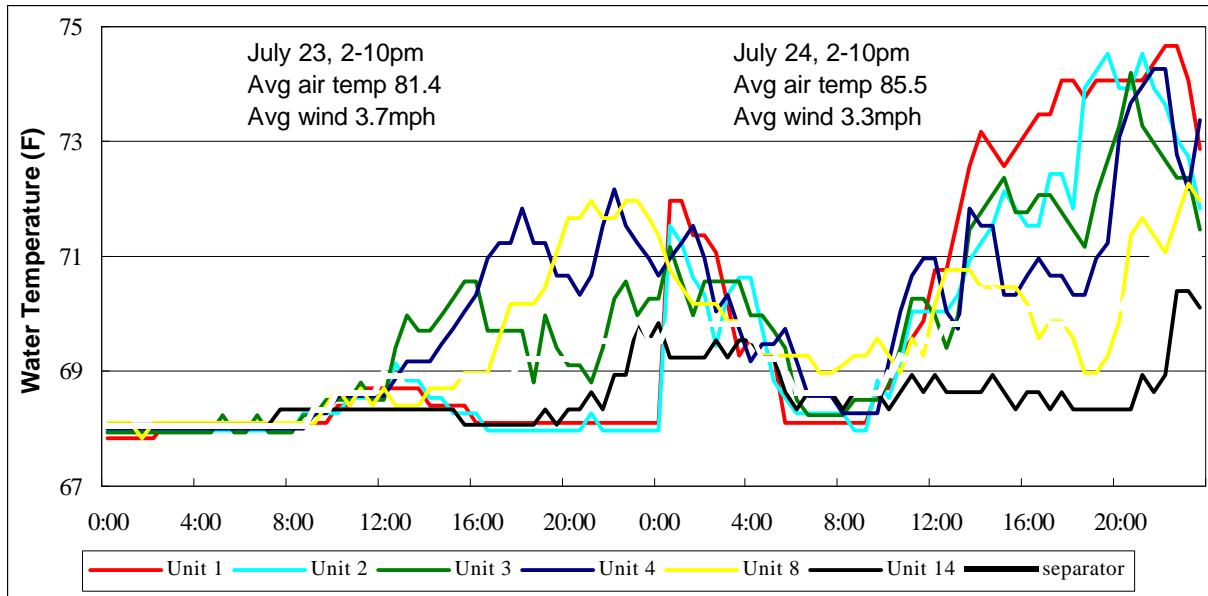


Figure 7. Side by side comparison of "off" versus "on" operation, July 23 and July 24.

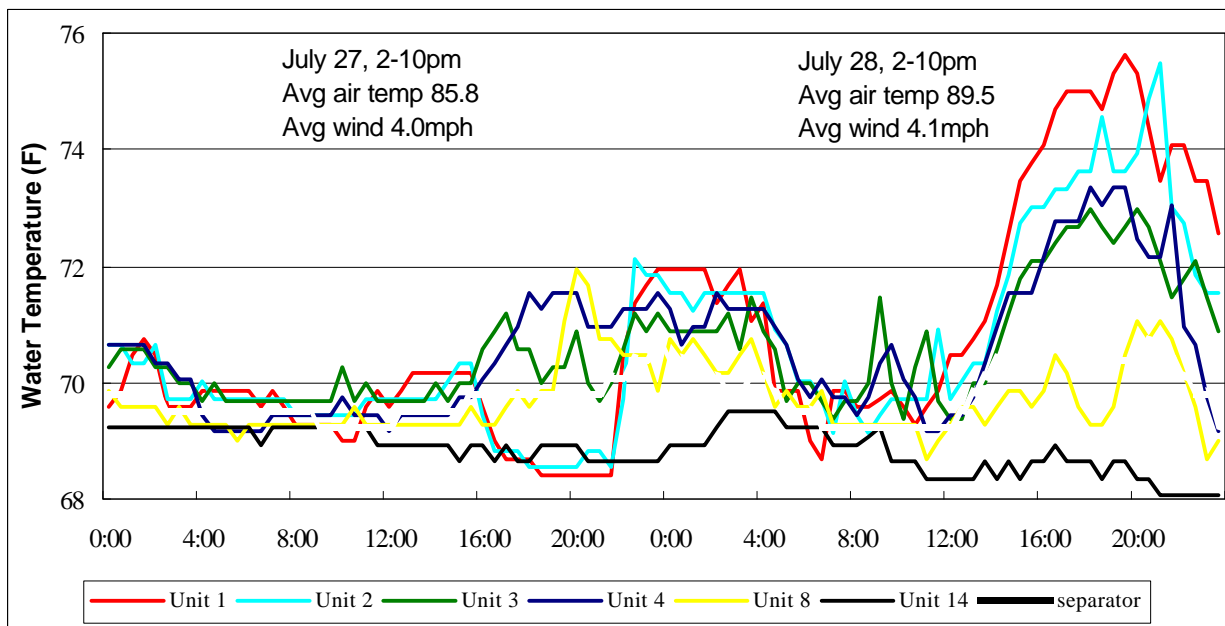


Figure 8. Side by side comparison of "off" versus "on" operation, July 27 and July 28.

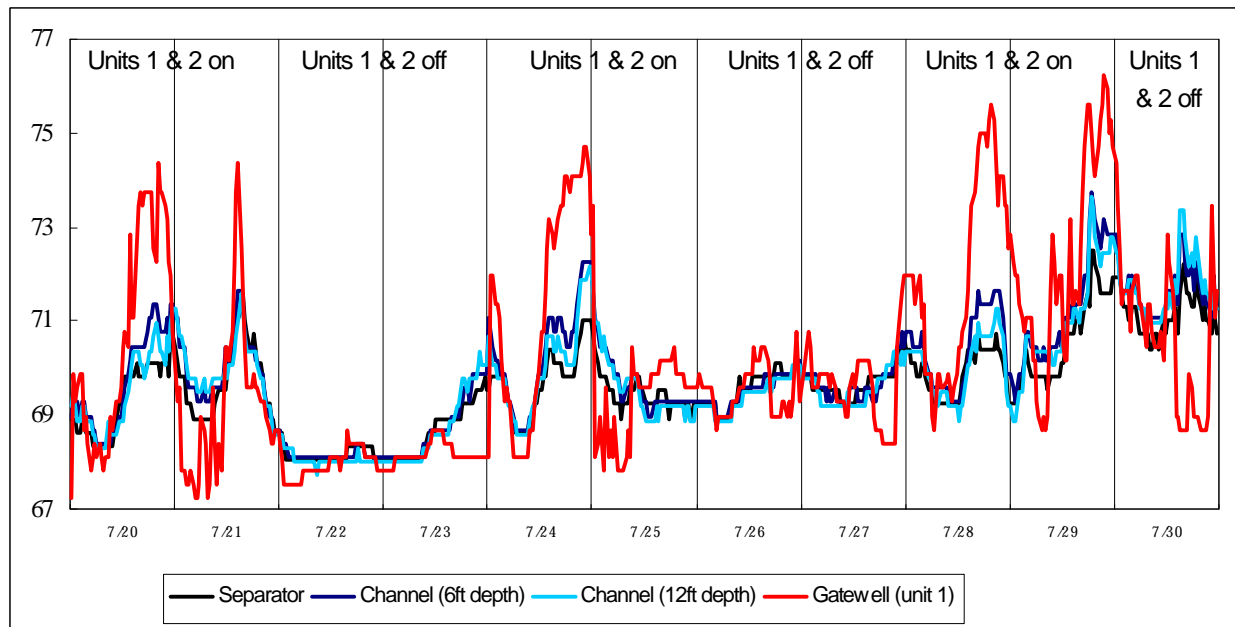


Figure 9. Separator, collection channel, and turbine unit 1 gatewell water temperatures during powerhouse operation testing.